



Armed Forces College of Medicine AFCM





Bone 1 (Bone Cells)

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INTENDED LEARNING OBJECTIVES (ILO)



By the end of this lecture the student will be able to:

- 1. List** the components of bone.
- 2. Describe** the microscopic structure of the bone cells.
- 3. Correlate** the microscopic structure to the function of the bone cells
- 4. Compare** between different types of bone and cartilage cells
- 5. Interpret** the defective microscopic bone structure in various diseases



Key Points



- Microscopic structure & function of different types of bone cells (osteogenic, osteoblasts, osteocytes & osteoclasts).
- Site, origin & function of matrix vesicles.
- Differentiate between osteoblasts & osteoclasts.
- Differentiate between chondrocytes & osteocytes.
- Diseases which affect bone.

Bone



Definition

Bone is a strong weight bearing form of connective tissue characterized by its solid stony hard intercellula

Function

- 1)It forms the skeleton of the body.**
- 2)It protects the vital organs.**
 - Heart and lung in the thoracic cage.**
 - Brain in the skull.**
 - Bone marrow in the medullary cavity of long bones.**
- 3)It acts as a reservoir for calcium.**
- 4)It gives attachment to the muscles and tendons.**



<http://www.jeeyopetct.com/wp-content/uploads/2017> pg



Bone consists of:

Bone cells

Bone Matrix

C.T. covering

**Fiber
s**

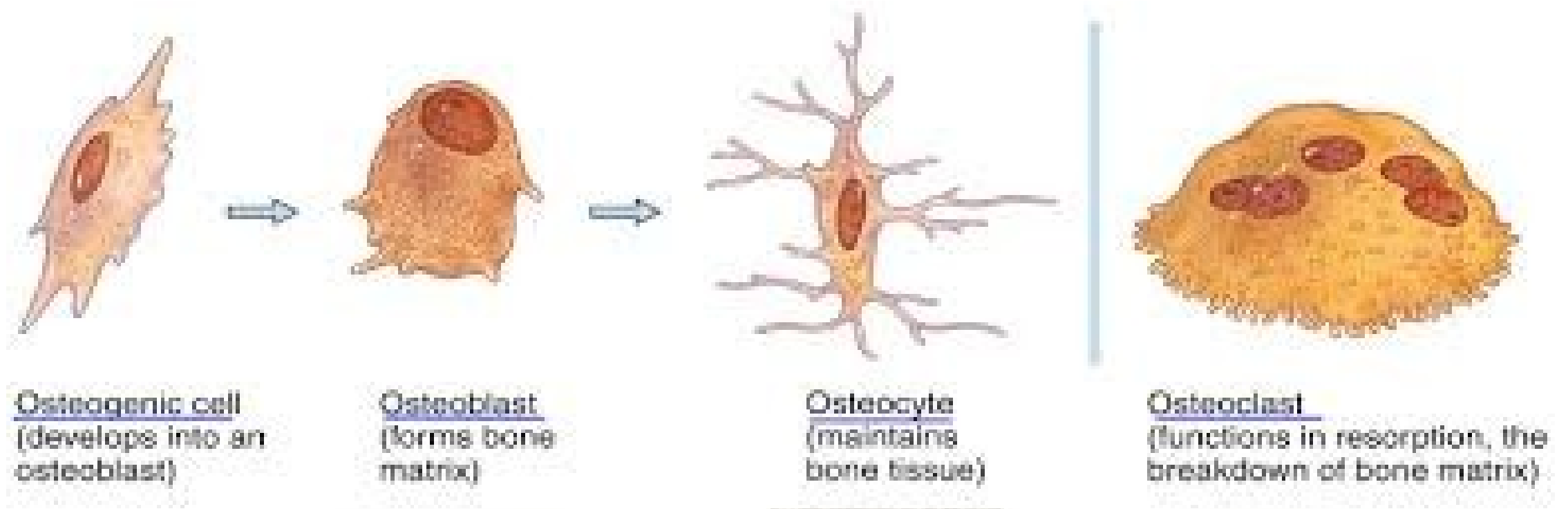
**Ground
substance
s**

Periosteum
(on external
surface)

Endosteum
(on internal
surface)



Bone Cells



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New Five Year Program

Musculo-skeletal Module



Bone Cells

1)Osteogenic cells:

Origin: UMCs and pericyte.

Site: In the inner osteogenic layer of the **periosteum and the endosteum.**

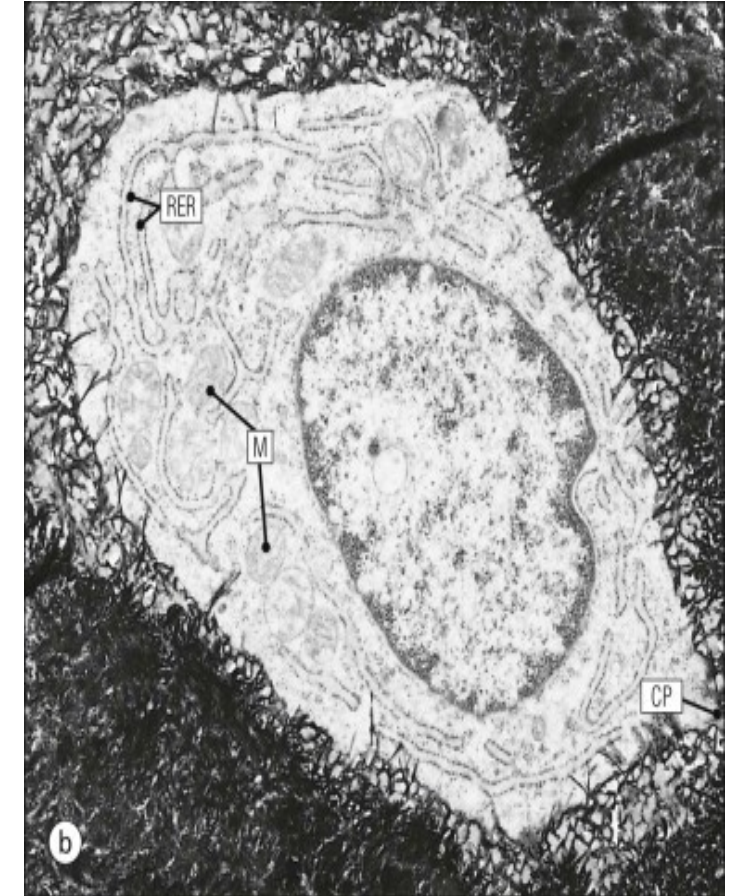
LM:

• Nucleus: central vesicular Cytoplasm: basophilic

E.M: abundant ribosomes, r ER , few Golgi complex, and mitochondria.

Function: They are dividable cells.

- They divide and differentiate into **osteoblasts** in presence of blood vessels and /or good oxygen tension.



<https://ars.els-cdn.com/content/image/3-s2.0-B9780723435020000139-f013-018b-9780723435020.jpg>

- **In absence of blood vessels and /or low**



Lecture Quiz



- All the following statements are true concerning osteogenic cells EXCEPT:

- a-They are derived from UMCs.
- ☒ b-Can differentiate to osteoclast
- c-Are found in both periosteum and endosteum
- d-May change into chondroblasts in low oxygen



2) Osteoblasts:

Origin: osteogenic cells (good O2)

Site: in the inner osteogenic layer of periosteum and endosteum.

LM:

Shape: large cuboidal or columnar cells, with few cell processes.

Cytoplasm: deep basophilic, -ve Golgi image near the nucleus (unstained Golgi body)

Nucleus: vesicular and eccentric

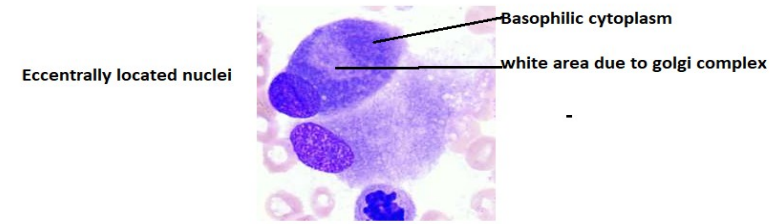
Protein-secreting cell

E.M:

- Ribosomes, rER, Golgi complex, secretory vesicles (matrix vesicles) and mitochondria.

- Cell processes connect one cell to the other and to nearby osteocytes by Gap

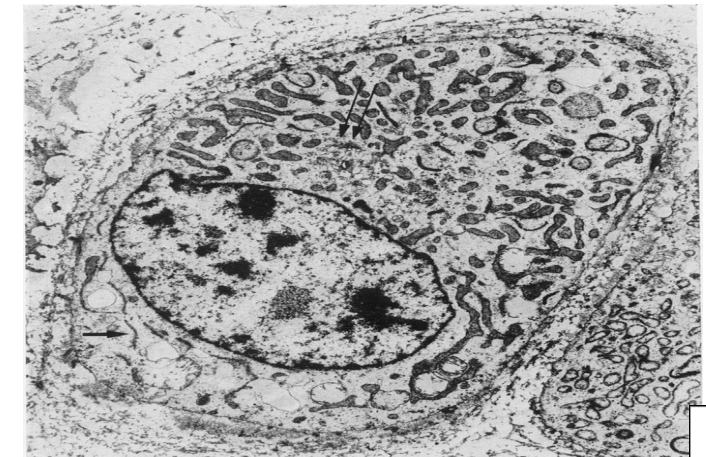
Osteoblast



https://1.bp.blogspot.com/-8hJJ_8_D-5g/XEgGa7NuPjI/AAAAAAAAO-l/qQGdceyGfksSGzwrP31_jWGsXsC5jIEWQCLcBGAs/s1600/osteoblast.png



<https://www.google.com.eg>



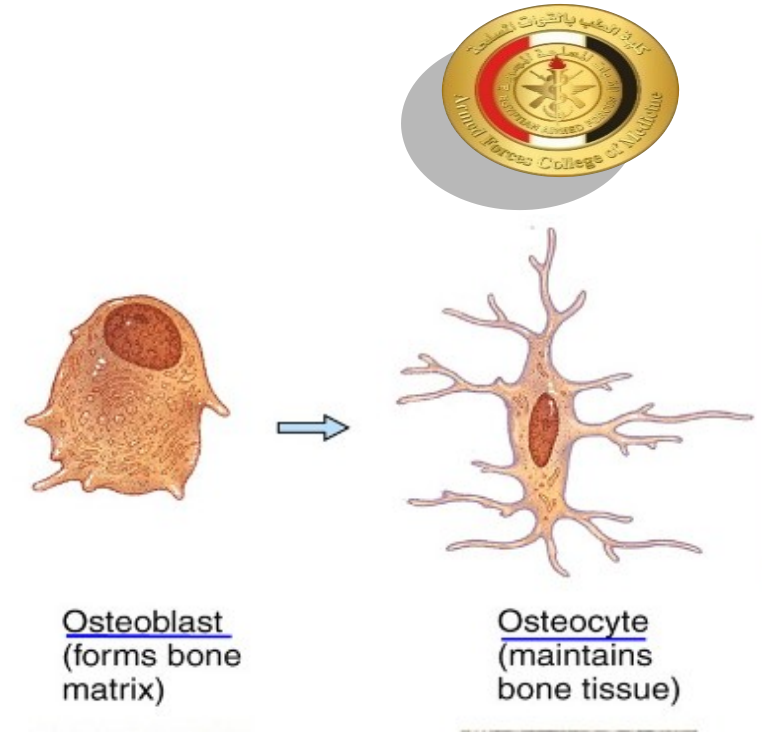
https://www.researchgate.net/profile/Michele_Allouche/publication



Function: non dividable cells

- 1) They are responsible for the synthesis and secretion of **organic component** of the intercellular substance (**osteoid tissue**).
- 2) Formation of **matrix vesicles** which cause calcification of the osteoid tissue (**ossification**).
- 3) They will be surrounded by bony matrix and **differentiate into osteocytes**.
- 4- Osteoblasts have parathyroid hormone (PTH) receptors on their surfaces.

↓ calcium blood level → secretion of **PTH** → stimulate release of **osteoclast stimulating factor** from **osteoblasts** → activation of



<https://www.google.com.eg/>

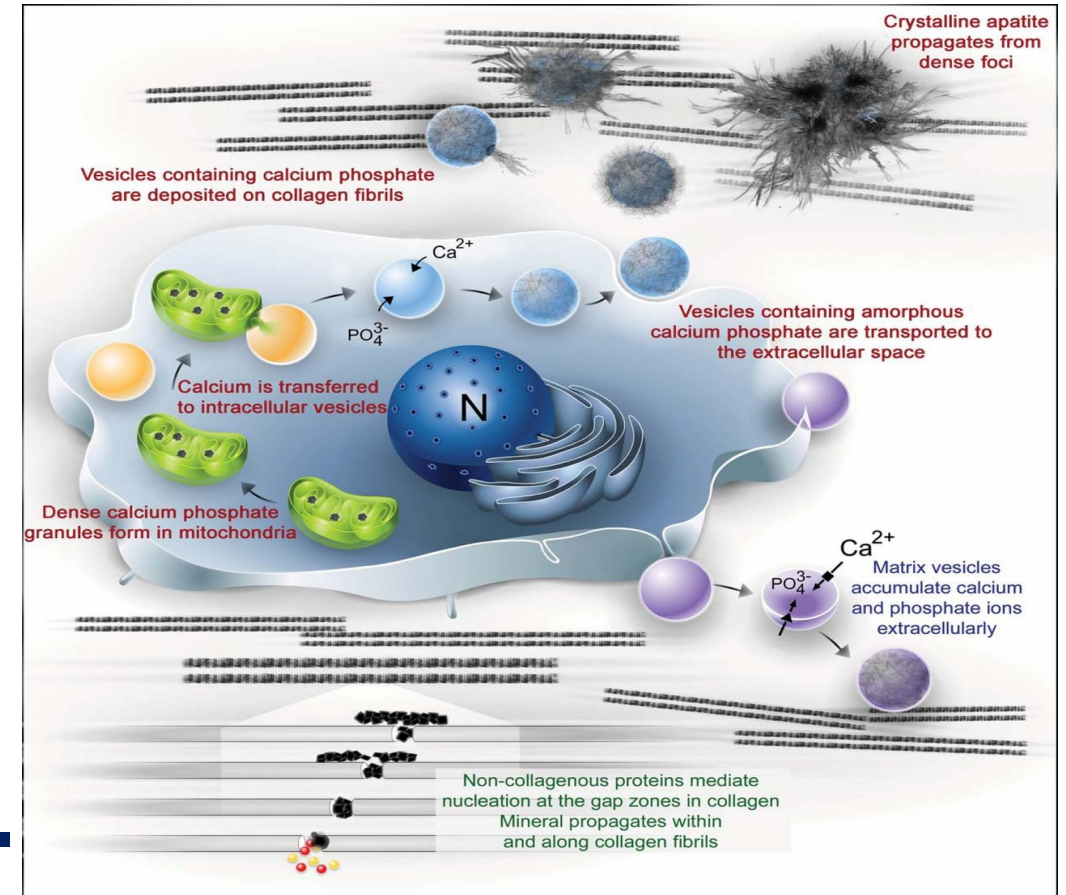


Matrix Vesicles



Site: small membranous structures in the matrix of cartilage, bone and at any site of calcification.

Origin: by budding from the cell membrane of osteoblasts, osteocytes and chondrocytes.



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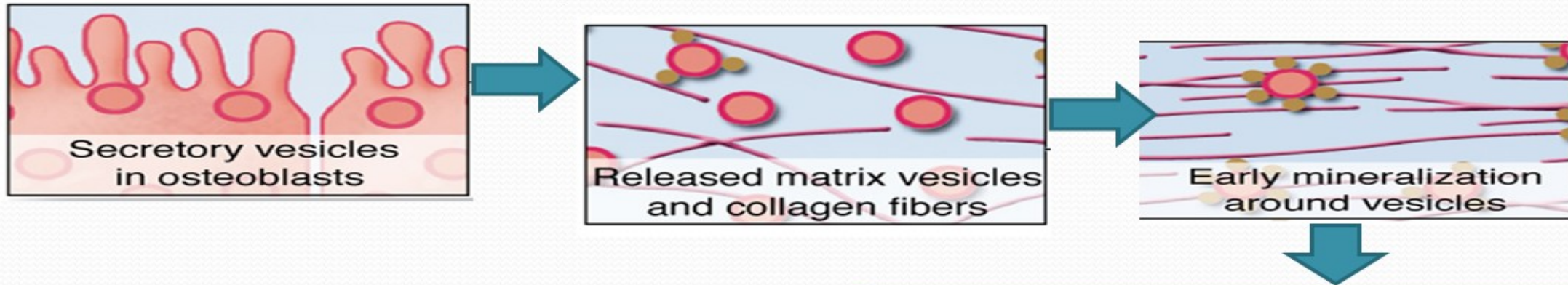


Function:

initiate calcification of the surrounding tissue by one or both of two mechanisms:-



1. They cause **precipitation of calcium salts** (Ca phosphate) by their content of **alkaline phosphatase enzyme**.
2. They **destroy and inhibit the inhibitors of calcification** by their content of **pyrophosphatase enzyme**.



https://accessmedicine.mhmedical.com/data/books/2355/janson_fig-13-07.png



Lecture Quiz



- Osteoblasts are derived from:

- ☒ a-Osteogenic cells
- b-Chondrocytes
- c-Osteocytes
- d-Osteoclasts

- All the following are true concerning osteoblasts EXCEPT:

- a-Show high alkaline phosphatase activity
- b-Have a well developed r ER and Golgi complex
- c-Synthesize and secrete all the organic components of the matrix
- ☒ d-Connected to each other by tight junction





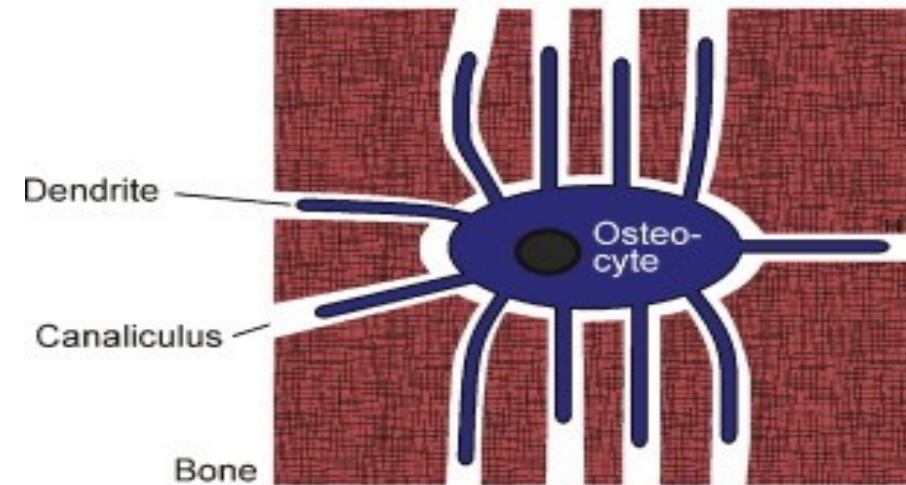
3) Osteocytes:

Origin: osteoblasts

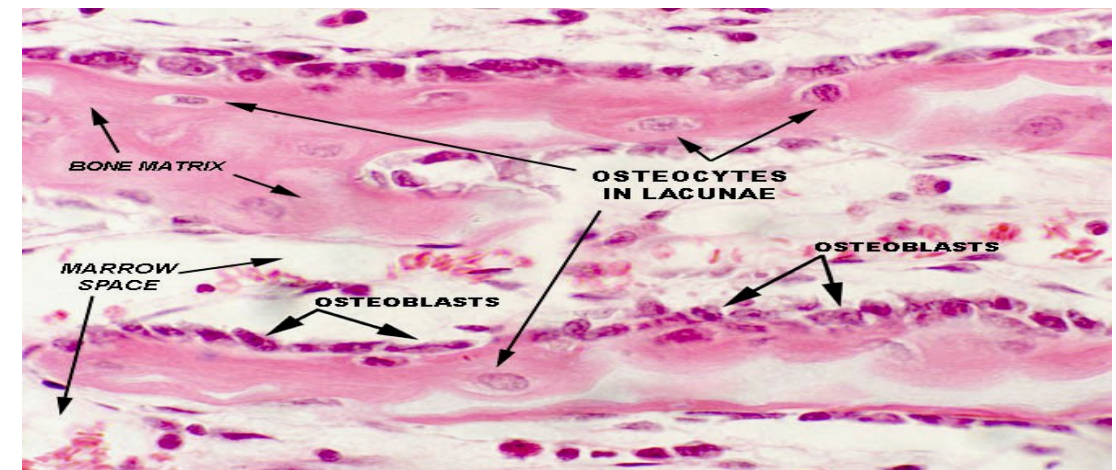
Site: in lacunae in the calcified matrix.

LM

- Shape: oval branched cells with cytoplasmic processes that pass in small canaliculi
- Cytoplasm: pale basophilic
- Nucleus: central, oval and deeply stained



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E.M:

- rER, ribosomes, Golgi complex, and mitochondria.
- Cytoplasmic processes of one cell joined to other cells by **Gap junction** to allow passage of electrolytes between cells.

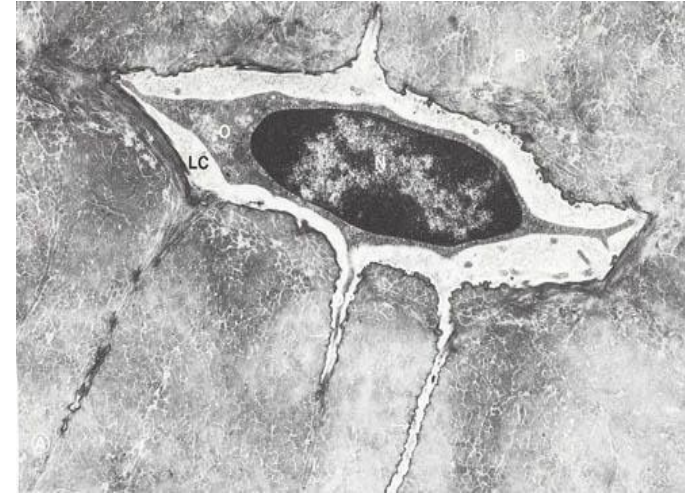
Function:

Maintain the bone matrix by:

a) Liberation of **matrix vesicles** which is responsible for matrix calcification.

b) Inhibitory factor to osteoclasts activity.

Fate: it does not have the ability to divide (end cell)



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4) Osteoclasts

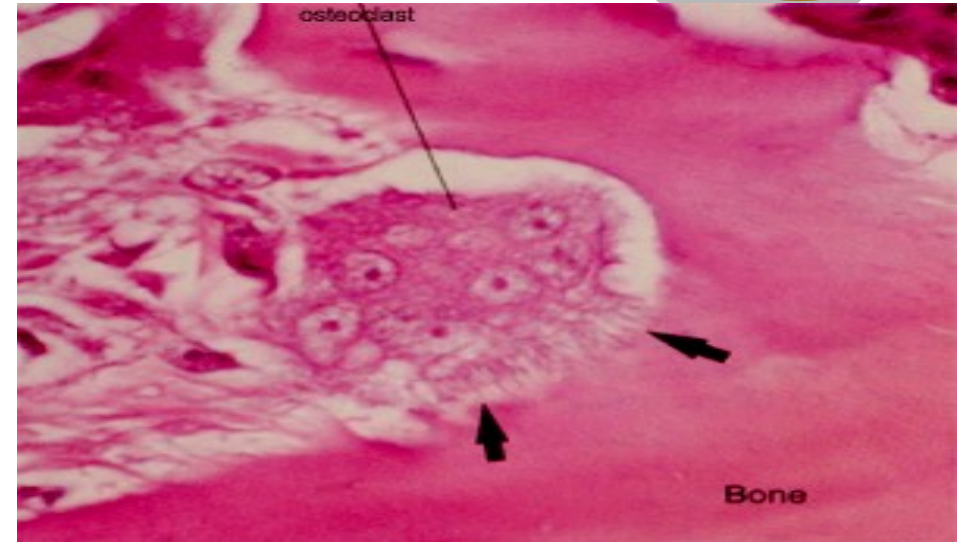
Origin: bone marrow precursors

Site: bone surfaces where **bone resorption** takes place (endosteum and in bone marrow cavities).

❖ It is present in a shallow depression called **“Howship’s lacuna”**

LM:

- **Shape:** large irregular motile cell
- **Cytoplasm:** foamy **acidophilic** with striated (brush) border facing the bone surface.
- **Nucleus:** **multinucleated** (up to 50 nuclei)



<https://www.google.com.eg/url?sa=i&rct=j&q=&esrc=s&source=images&cd=&ved=2ahUKEwier-SEhJHiAhWwA2MBHRM9AYQQjRx6BAgBEAU&url=http%3A%2F%2Fwww.poolia.info%2Fosteoclasts.html&psig=AOvVaw05BdABfSMXjGWHKfxkO8H8&ust=1557580034012026>

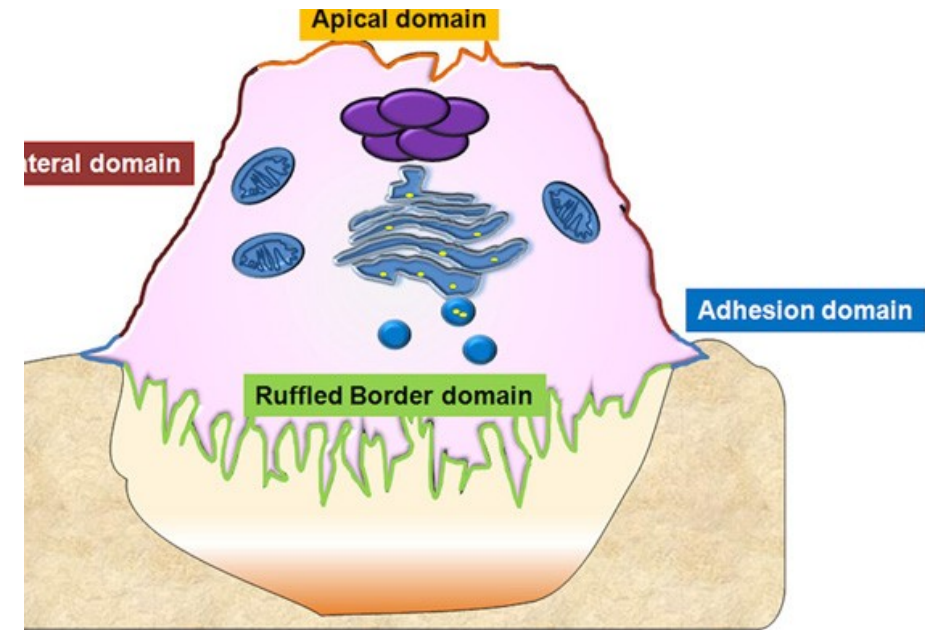


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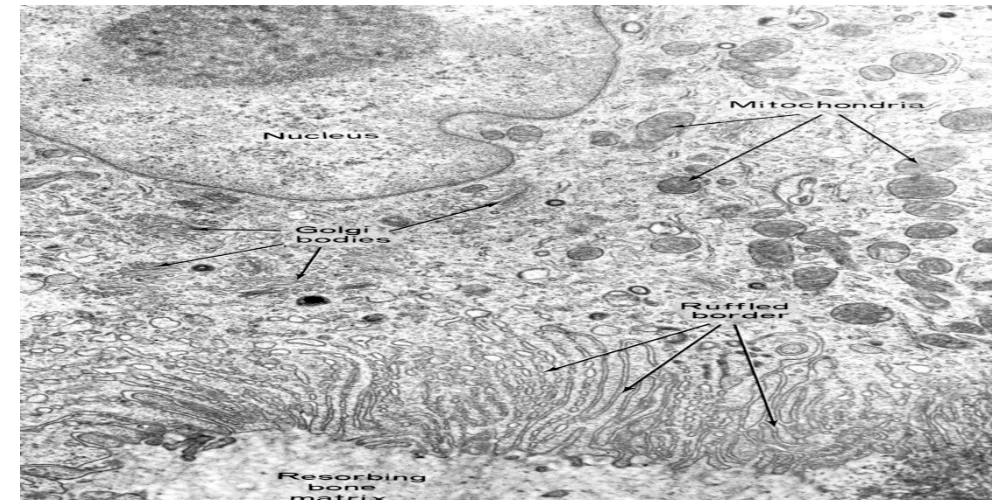


E.M: four zones are distinguished :

- 1) Ruffled border zone:***
Finger-like processes of the cell membrane, projecting into the site of **bone resorption.**
- It contains actin filaments.
 - It is highly motile.
 - It secretes **acidic medium** to dissolve inorganic salts.



<https://www.bioscience.org/2012/v4e/af/543/fig5.jpg>

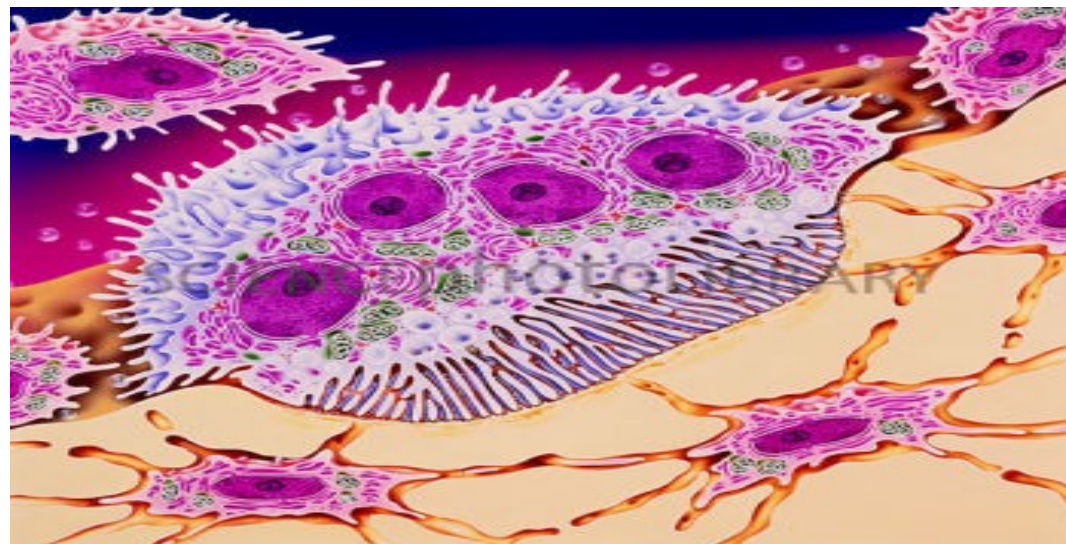


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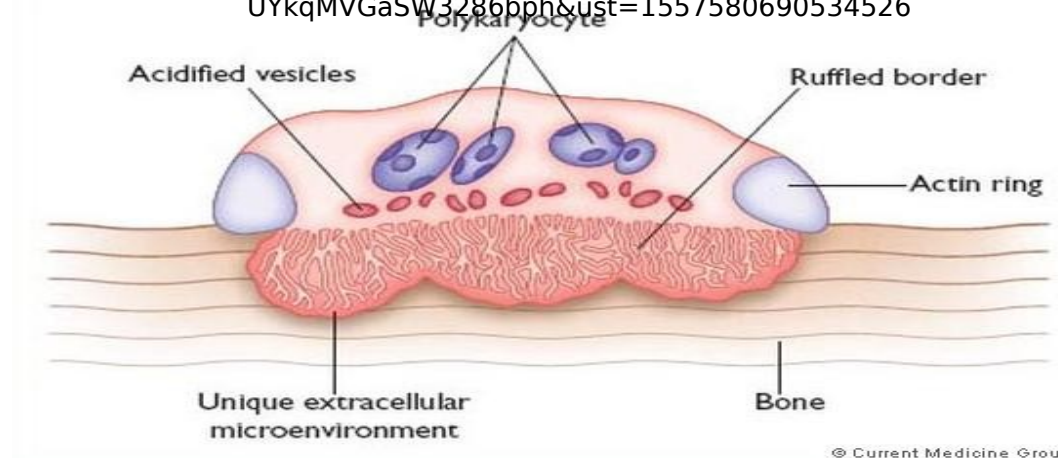


2) *Clear zone:*

- Ring-shaped area surrounding the ruffled border.
- It contains actin like filaments.
- It is responsible for **localization** of the cell secretion and also for **fixation and movement** of the cell along the bone surface.



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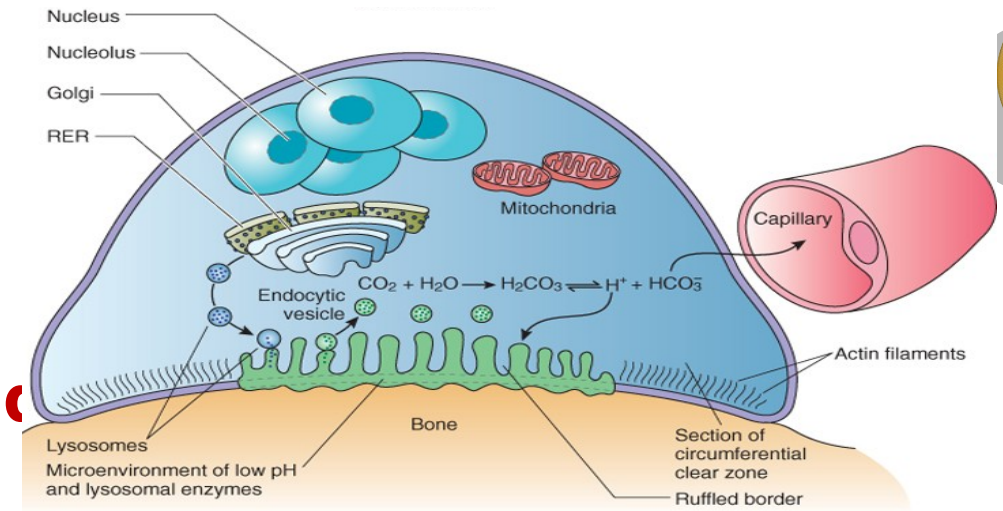
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<https://i1.wp.com/extras.springer.com/2009/978-1-57340-296-5/images/01/0102/large/ACE0303-02-018.jpg>



3) *Vesicular zone:*

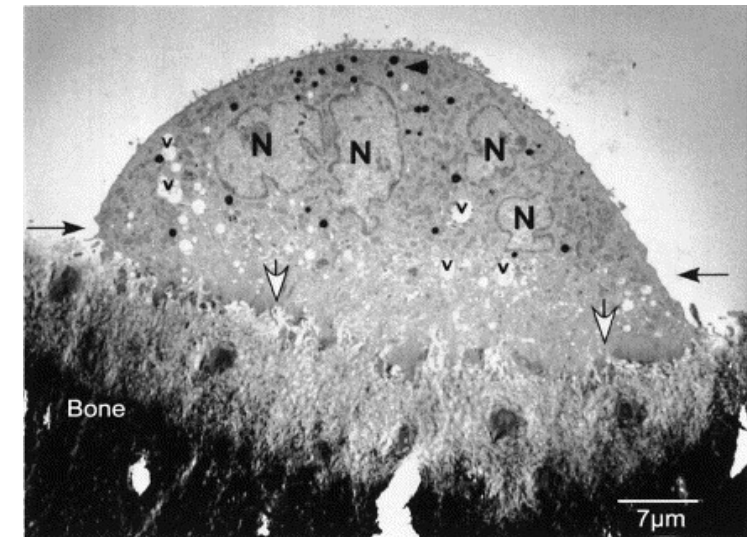
* This zone contains **vesicles and vacuoles** .



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There are two types:

1. Exocytotic vesicles; containing **lysosomal hydrolytic enzymes**
2. Endocytotic vesicles; containing **resorbed bone debris**

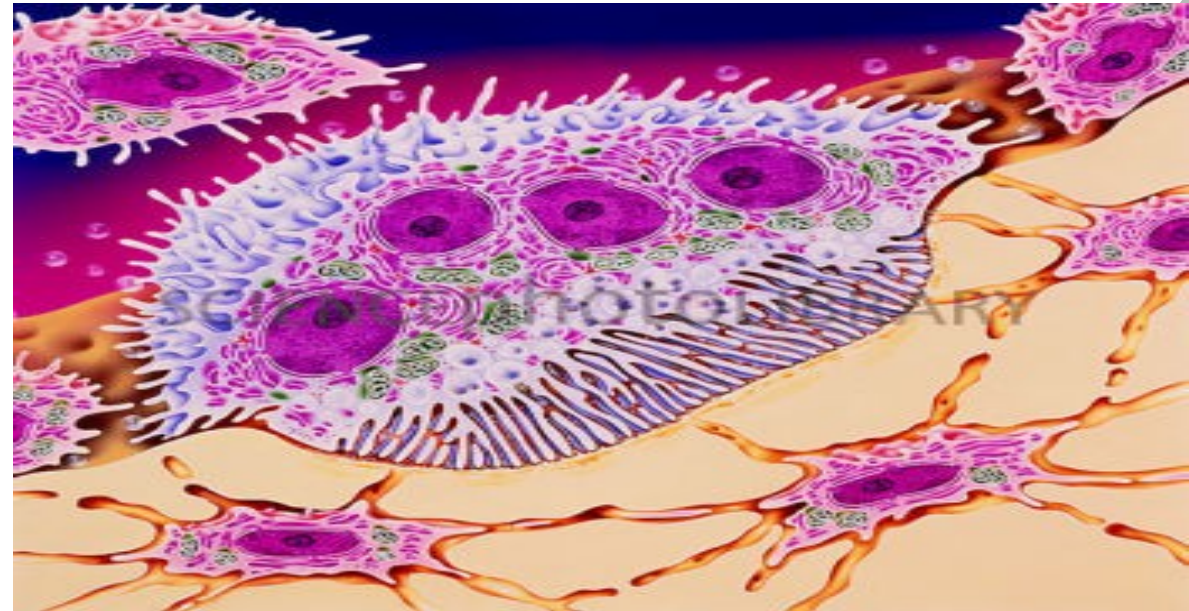


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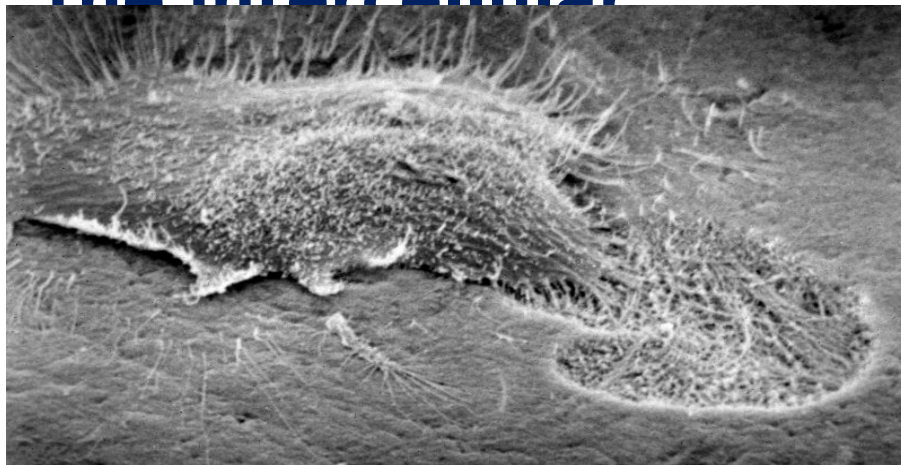


4) *Basal zone:*

It contains **multiple nuclei** and **cell organelles** which are responsible for the secretion of enzymes that dissolve the organic component of the intercellular



<https://www.google.com.eg/>



https://boneresearchsociety.org/media/gallery/4l.jpg.200x150_q85_autocrop.jpg



<https://i.pinimg.com/originals/45/66/c1/4566c158042f80f1d4c0cacc4d64296b.jpg>



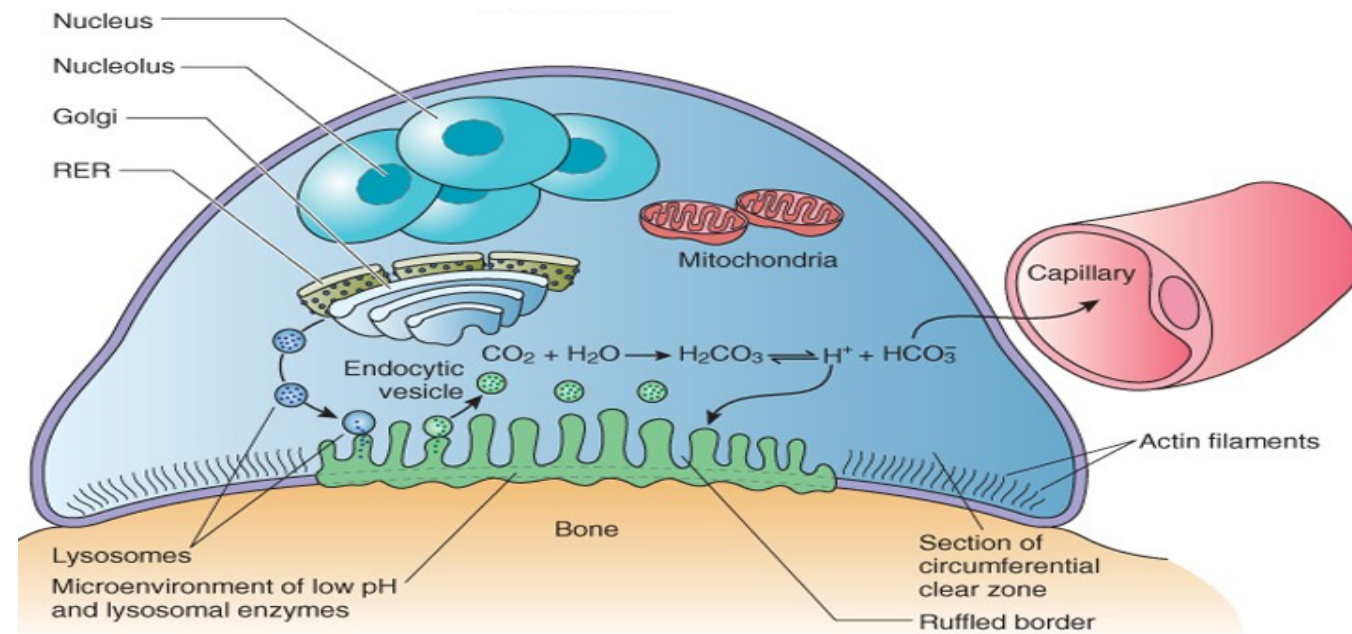


Function:

- It is responsible for **bone resorption** and it takes an essential role in **bone remodeling**. This is achieved by:
 - 1) Creates an acidic medium to **dissolve inorganic salts**.
 - 2) Secretion of hydrolytic enzymes that **digest organic constituents of bone matrix**

- They control calcium level in blood under the control of **parathormone** and **calcitonin hormones**.

- 3) They have a **phagocytic activities**



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https://images.slideplayer.com/15/4556545/slides/slide_22.jpg





Give reason for “Explain”

The presence of brush border of osteoclast by LM

- *Their ruffled border “finger like projection”
- *Exposed collagen fibrils after digestion of matrix





Osteoclast	Osteoblast	
Stem cell in bone marrow	Osteogenic cell in good O ₂	Origin
Endosteum only	Inner osteogenic layer of periosteum and in the endosteum	Site
Non branched cell with brush border toward bone surface	Branched cell	Shape
Acidophilic cytoplasm	Deeply basophilic with -ve Golgi image	Cytoplasm
multinucleated	Single eccentric	Nucleus
4 zones: ruffled, clear, vesicular and basal zones	RER, Golgi, mitochondria and matrix vesicles	EM
For calcitonin and osteoclast stimulating factor	For PTH	Receptors
Bone resorption	Bone formation	Function





Osteocytes	Chondrocytes	
Osteoblast	Chondroblast	Origin
Oval	Oval or round	Shape
Branched	Not branched	Cytoplasmic branches
Present singly in lacunae	Present singly OR in groups in lacunae	Number in lacunae
Can't divide	Can divide	Division
No Interstitial growth in bone	Responsible for interstitial growth of cartilage	Function



Medical Applications



Osteopetrosis

Genetic disease characterized by **lack of ruffled border of osteoclast**
causing defect in **bone resorption** → **increase in thickness of bone**
narrowing of bone marrow spaces → **decrease in blood**
cells formation → **decrease in red blood corpuscle** → **anaemia**



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Osteoporosis

In immobilized patients and post menopausal women, **bone resorption exceed bone formation** → **Calcium loss from bone** → **decrease bone mineral density** → **bone becomes liable to fracture**



https://i.dailymail.co.uk/i/pix/2011/04/22/article-0-0636C622000005DC-961_472x306.jpg



Lecture Quiz



-Bony canaliculi are defined as :

- a-Connection between Haversian canals
- b-Cytoplasmic extensions from osteoblasts
- ☒ c-Channel like structure containing the processes of osteocytes
- d-Bony trabeculae

- Osteoclasts:

- a) Are small immotile cells
- ☒ b) Have multiple nuclei
- c) Have deep basophilic cytoplasm
- d) Are present in lacunae inside bone matrix



Key Points



- Microscopic structure & function of different types of bone cells (osteogenic, osteoblasts, osteocytes & osteoclasts).
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- Differentiate between chondrocytes & osteocytes.
- Diseases which affect bone.

Summary



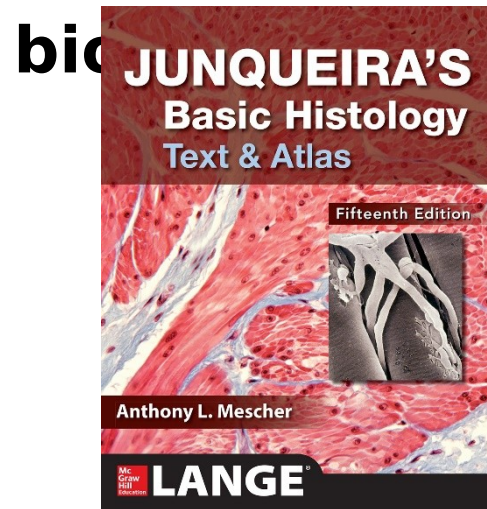
1. Bone is a special type of C.T. with stony hard matrix
2. Bone cells are: osteogenic, osteoblast, osteocyte and osteoclast
3. Osteogenic cells are the stem cells of bone
4. Osteoblasts are the bone forming cells and are not present in lacunae
5. Osteoclasts are the bone resorbing cells
6. By EM the osteoclast has four zones; from the bone surface they are ruffled border, clear zone, vesicular zone and basal zone



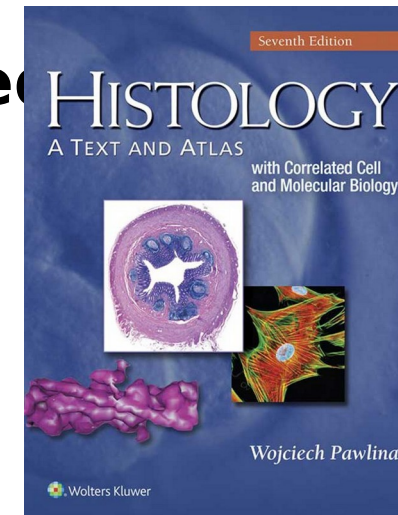
SUGGESTED TEXTBOOKS



- 1. Junqueira's Basic Histology: Text and Atlas, 15th Edition by Anthony Mescher (2018)**
- 2. Histology a text and atlas with correlated cell and molecular**



Pawlina 7th ed (2016)



THANK
YOU

